

PALEONTOLOGY.—*Morphology and taxonomy of the foraminiferal family Elphidiidae.* MARY WADE, University of Adelaide, South Australia. (Communicated by Alfred R. Loeblich, Jr.)

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The morphology of species of *Elphidium* and related genera is herein described, and the taxonomy of the group is discussed. *Elphidiella* Cushman is suppressed as a synonym of *Elphidium* Montfort. A new species of *Parrellina* Thalmann is described. Australian fossil species correctly referred to *Elphidium*, *Parrellina*, and *Notorotalia* are listed.

MORPHOLOGY

In the classification of the family Elphidiidae Galloway (1933, as Elphidiinae) the following characters are used: (1) The presence or absence of retral processes; (2) a complex canal system; (3) the diameter of the perforations in the wall; (4) the wall-structure; (5) the ornamentation; and (6) the coiling.

1. *The retral processes.*—Carpenter (1862, pp. 278-279; pl. 4, fig. 28; pl. 16, figs. 6, 7, 9) regarded "retral processes" as "a set of processes . . . of sarcode . . . which extend backwards for a short distance from both the outer or lateral margins of each segment of the sarcode body." In describing *Elphidium craticulatum* (as "*Polystomella*") he said (p. 282): "The spiral lamina which forms the outer wall being modelled (so to speak) upon the surfaces of these retral processes, presents internally a corresponding series of grooves, which are deepest towards the posterior margin, and become rapidly shallower in passing towards the anterior margins, of each chamber." Evidence of retral processes, therefore, should not be sought on the outside of the test, but inside the chamber lumina. Later workers, concerned with the external appearance of the test rather than its detailed internal characters, have interpreted the external ridges which partially enclose the retral processes of protoplasm as "retral processes." An example is in the definition of the Elphidiidae given by Loeblich and Tappan (1953) and quoted by Smout (1955), "with retral processes projecting across the sutures." Parr (1950) spoke of *Parrellina* Thalmann, 1951 (as *Elphidioides* Parr 1950), having no "true retral processes."

An examination of the inside of broken or dissected empty tests (including those in Parr's material) shows a row of small indentations around the septal sutures, which must have covered retral processes in Carpenter's sense. Such small hollows may house small retral processes without being noticeable externally, or, according to their size, they may underlie small ridges showing on the walls of the last few chambers, as in *E. craticulatum*, or very large ridges as in *E. crispum*.

Carpenter (p. 282) differentiated between the internal "grooves" (underlying the external ridges) which house the retral processes of *E. craticulatum*, and the large, deep depressions of *E. crispum* "completed into tubes for part of their length by an additional lamella of shell given off from the septum". This difference seems to be one of size rather than structure (Figs. 1, 2, [7]). In fossil species the presence of indentations (grooves, tubes, hollows) in the chamber wall around the proximal edges of the chamber lumina is reliable evidence of protoplasmic retral processes. As the modification of the chamber walls indicates the retral processes, the indentations may be called retral processes without confusion.

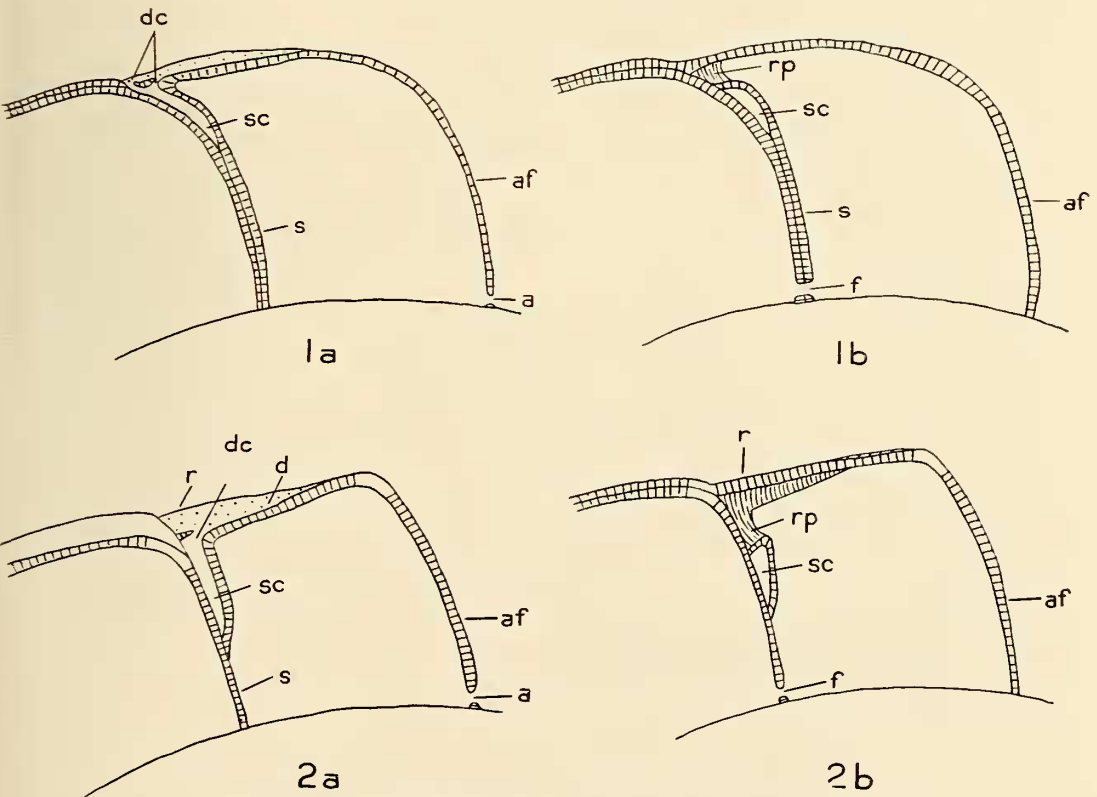
After a detailed study of *E. crispum*, using both thin sections and internal moulds, Ujiie (1956) criticised Carpenter's results. He stated that the retral processes (which he called "septaspirothecal stolons") lead into the lumen of the preceding chamber. These conflicting views are reconciled by a study of broken and dissected specimens. The retral processes of the last chamber end blindly against the septal face, being separated from the canal system by a fold of the septal flap (Figs. 2b, 3). In earlier chambers a minute pore appears by resorption in the septum at the base of each retral process. As still earlier chambers are investigated the pores are seen to enlarge until they occupy the base of each retral process, placing the chamber lumina in communication with each other through a series of short tubes, the lateral walls of the retral processes. It does not seem desirable to

introduce a new name such as "septa-spirothecal stolons" for retral processes in chambers other than the last, which have been placed in communication with the preceding chambers by partial resorption of the septa. The structure is not synonymous with those commonly called apertural or foraminal stolons in other groups of Foraminifera. Ujiie noted the breakdown of the septal walls in several species with large retral processes. It also occurs in species with moderate-sized retral processes but would be very difficult to observe, and may not occur, in those with very small retral processes. As Carpenter said, only the basal ends of the retral processes are tubular, the tubes being formed from the septal flap and the adjacent ridges on the chamber walls (Fig. 2). The remainder of the grooves below the tapering external ridges open into the chamber lumina, as Hofker (1956, p. 153) has again described. This fact does not fit Ujiie's interpre-

tation of his internal moulds (1956, p. 271; Figs. 1, 2), since he states that the "septa-spirothecal stolons" are enclosed in complete cones which open to the surface by a fine pore. These pores have not been observed by the writer.

2. *The canal system.*—Carpenter and Ujiie both drew attention to the thickening of the outer wall of the test during growth. Carpenter (p. 280) noted that the "exogenous deposit" was "continuous with that of which the central nucleus is composed." He stated (p. 50, fig. 8) that this thickening of the wall characterized all the higher "vitreous" Foraminifera. Smout (1954, 1955) has shown that it is due to the enclosing of the whole test in a layer of shelly material each time a chamber is added; this is characteristic of the Rotaliidea as a whole, as Carpenter's description indicated.

The canal system is enclosed between the



FIGS. 1, 2.— 1a, b: *Elphidium craticulatum* (Fichtel and Moll); 2a, b: *E. crispum* (Linné). In each figure, a is a diagrammatic view of the last chamber cut through one of the surface depressions, and (b) a corresponding view cut through one of the ridges which separate the depressions. (Abbreviations: a—aperture; af—apertural face; d—surface depression; dc—diverging canal; f—foramen; r—surface ridge; rp—retral process; s—septum; sc—septal canal.) Approximately $\times 300$.

initial wall of the chamber (the septal face) and the septal flap, that part of the succeeding chamber which is attached to the septal face. If retral processes are present to indent the septal flap and carry the outer chamber-wall which follows them back to the previous chamber, the septal canal is deeply buried (Figs 1, 2) and communicates with the surface by diverging canals. If no retral processes are present the septal canals are roofed by part of the layer of shell material which encloses the test during growth; if this material becomes sufficiently thick diverging canals are again formed. In *Elphidiella arctica* (Parker and Jones) and *Elphidium subnodosum* (Münster) the roofing layer is perforate like the remainder of the wall (Hofker, 1956). In *E.*

subnodosum it often breaks down near the margin and leaves the septal canals open as fissures. Hofker (1956) says that the septal canals of *E. arctica* lead to the surface at either side of the periphery of the test, and are not complete from one side to the other. He also says that the roofing layer is imperforate above the canal system in *Elphidium oceanicum* Cushman, and from his figure (pl. 24, fig. 3) this species appears to lack retral processes. It is hard to see an essential difference between these simply buried canal systems, and that so clearly figured by Hofker (1956, pl. 21, figs. 14, 15) for *Elphidiononion poeyanum* (d'Orbigny), type species of *Elphidiononion* Hofker.

The full development of elphidiid canal

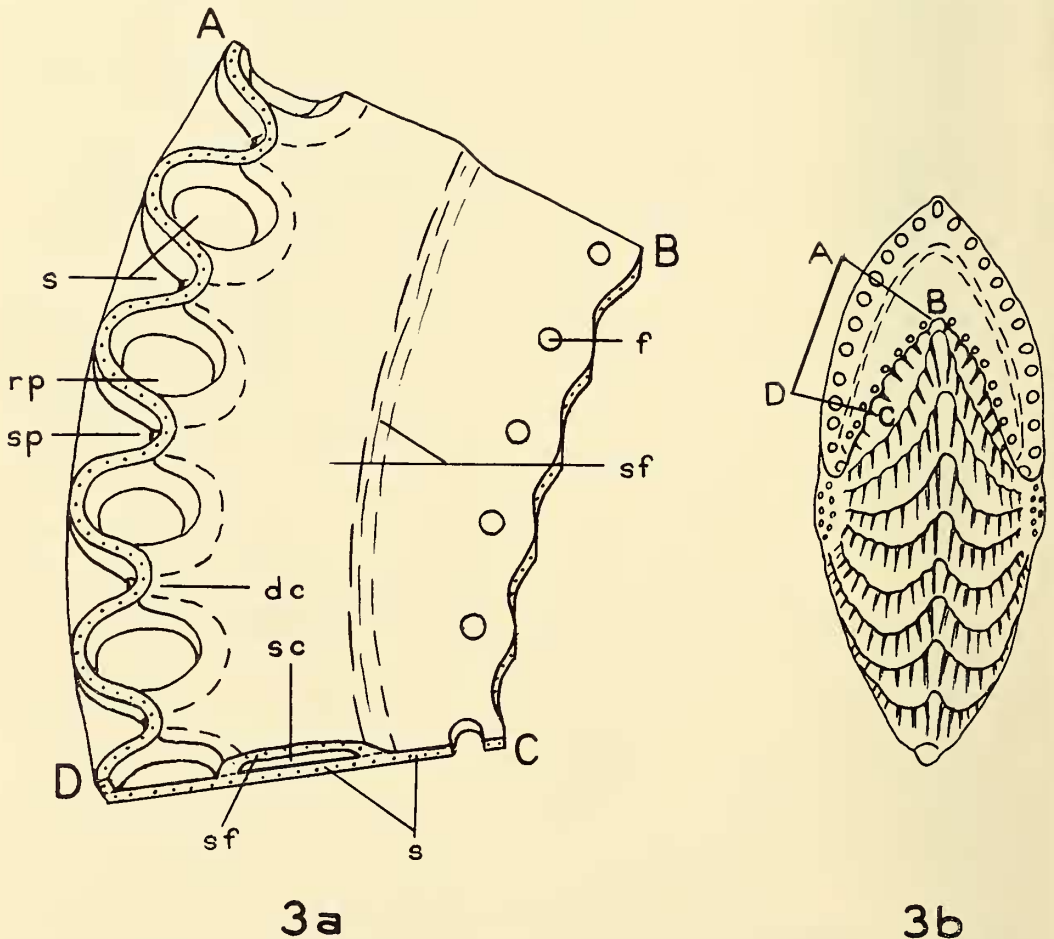


FIG. 3.—*Elphidium crispum* (Linné). *a* (approximately $\times 400$) is an enlargement of the area marked ABCD in *b*. It represents the "apertural" view of a specimen lacking the last chamber. (Abbreviations: *dc*—diverging canal; *f*—foramen; *rp*—retral process; *s*—septum; *sc*—septal canal; *sf*—septal flap; *sp*—septal pore.)

systems, which is seen in *E. craticulatum*, was well described by Carpenter (1862). Its understanding has been amplified very ably by Hofker (1927, 1956) for numerous species of elphidiids. Typically there are spiral canals following the umbilical margins of the chambers. In forms with umbilical plugs, these give rise to straight, unbranched canals which lead to the surface of the plugs. A peculiarity of *Parrellina* Thalmann is the presence of anastomosing umbilical canals in place of spiral canals. Hofker (1956, p. 156) explains the lack of radial umbilical canals in *Elphidiella arctica* as due to the inner ends of the chambers overlapping the spiral canals, and this appears to be so in a number of the more involute forms. The spiral canals or the anastomosing canals give rise to subsutural septal canals at each septum. These may be complete, or those from each side may open to the surface by a pore on either side of the periphery, a condition which Hofker considers more primitive. In *E. subnodosum* the septal canals often become open fissures part-way to the periphery, though in other respects its canal system with well-developed spiral and umbilical canals is not primitive. Incomplete septal canals may be a specialized feature in this species at least.

In most species the septal flap does not cover the whole of the septal face of the preceding chamber, so that the septum as a whole is single-layered near the centre and base, and double near the outer edges, where it encloses the canal system. A few species which have massive walls have completely double septa, and these may enclose additional intra-septal canals between the two layers, as Carpenter (1862, pl. 16, fig. 1) figured in *E. craticulatum* and as can be seen in *Parrellina craticulatiformis*, n. sp. (Fig. 4, 2, 3, 6). Brotzen (1948) showed a connection between the spiral canal and chamber lumen in *Elphidiella prima* (ten Dam), and Hofker (1956) states that this is typical of all advanced elphidiid canal systems. The writer has observed it in several species, including those of *Parrellina*.

3. *The perforations of the wall.*—Hofker (1956) places great emphasis on the significance of the size of the perforations of the wall, and asserts that the presence of relatively coarse pores is always associated with a relatively primitive canal system, not connected to the lumina of the chambers, the absence of retral processes, and

the imperforate nature of that part of the test wall which roofs the canal system, and is divided into "pillars" by the septal pores. On the basis of these differences he removed several species from *Elphidium* to his genus *Elphidiononion* which he placed in the Nonionidae. The canal system, however, differs little from that of other elphidiids lacking retral processes, and Hofker has stated that the "pillars" roofing the canal system of *Elphidium oceanicum* are imperforate, like the "pillars" of *Elphidiononion*. It seems therefore that *Elphidiononion* is close to *Elphidium*.

4. *The wall-structure.*—The wall-structure was tested and found to be radial in topotypes of *Elphidiononion lidoense* (Cushman) and in *E. indieum* (Cushman); though no other species were available for examination, their agreement in described features suggests that they are likewise radial. This is typical of the Elphidiidae, and is a strong argument against a close relationship between *Elphidiononion* and the granular-walled *Nonion*.

5. *The ornamentation.*—Hofker (1956) showed that fine pustules of shell material, such as cover the whole surface of *Elphidium argenteum* Parr, are quite a common form of ornamentation. In some species it is localized to beading on the older chambers and sutures. Some elphidiids have raised ridges of shell material on the surface of the chambers "situated between the openings of the canals, and thus coinciding with the retral processes," as Hofker stated. *Parrellina* Thalmann has particularly thin, high bars of ornamentation. In some species they are a little irregular or may even be reticulate and only roughly coincide with the retral processes.

6. *The coiling.*—One uncoiled form, *Ozawaia* Cushman, has arisen whose young stages cannot be distinguished from *Elphidium*. Trochospirally coiled forms appear to have arisen several times. Of these *Faujasina* d'Orbigny and *Polystomellina* Yabe and Hanzawa are rather tenuously separated by the former being flattened on the evolute side and the latter flattened on the involute side. The species referred to *Notorotalia* Finlay are biconvex; their heavy ornamentation of transverse or reticulate ridges, usually with raised sutures, is strikingly similar to that displayed by *Parrellina imperatrix* (Brady) and related species, as both Finlay and Parr have said. It is most probable that they arose from

Parrellina independently of other trochoid forms. Hofker (1956, p. 163) has described the canal system of *N. clathrata* (Brady) very clearly. A similar bilateral canal system is present in *N. howchini* (Chapman, Parr, and Collins), which is widespread in the Middle Tertiary of South Australia. It has retral processes. *N. miocenica* (Cushman) from the Lower Miocene, Muddy Creek, western Victoria, has particularly large retral processes on the involute side. They are also present on the evolute side. The canal system is again bilateral (with septal pores on both sides). Another species which is widespread in the Middle Tertiary of South Australia is very close to, or may even be identical with, *N. tainuia* Dorreen (described from the Upper Eocene of New Zealand). It has retral processes with septal pores between them on the involute side, obscured by pustules of shell material which sometimes coalesce into transverse bars. The evolute side has no retral processes or septal pores, and no septal canal has been observed inside the test on the evolute side. As Hofker says that the canal system of *N. clathrata* develops on the evolute side after several chambers, the discovery of a species in which it is lacking is not surprising.

A form in which early planispiral growth is followed by annular growth is shown by the genus *Sherbornina* Chapman (Wade and Carter, in Press).

TAXONOMY

Brotzen (1948, pp. 70-71) has given the only satisfactory description of an early elphidiid, *Elphidiella prima* (ten Dam), Danian to Paleocene. *E. multiscissurata* Smout (1955), Macstrichtian, is well described externally, but details of the canal system are lacking. Apart from Hofker's descriptions (1927, 1956) the majority of the descriptions of Elphidiids are totally inadequate. As a result very little is known of the phylogeny of the group, or of what characters are generically important.

Hofker (1956), basing his opinion on Brotzen's description of *E. prima*, and on his own observation that species of *Elphidium* with both single and double rows of septal pores have the double rows in the microspheric generation, considers various characters "primitive" or "advanced." The lack of retral processes and double rows of septal pores such as are found in *E. prima*, together with incomplete septal canals like *E. arctica* (Parker and Jones), and very fine

perforations in the walls, he considers "primitive." Relatively coarse perforations, retral processes, complete septal canals, well-developed spiral canals, and single rows of septal pores are considered "advanced." According to whether a species shows more "primitive" or "advanced" characteristics he allots it to a genus. Such a subjective approach allows room for endless arguments as to which characters really are primitive and which specialized (advanced); also as to which primitive characters outweigh which advanced ones. Hofker's usage results in the recognition of the genera *Elphidiononion*, *Elphidium*, and *Elphidiella* (he does not take *Parrellina* into account). Each of his three groups is fairly uniform in itself, but for the most part shares each of the "generic" characters with various species in other genera. Two distinctive characters appear to separate the species referred to *Elphidiononion* from those referred to *Elphidium* and *Elphidiella*: they have fewer, coarser perforations in the walls, and according to Hofker their canal systems do not communicate with the chamber lumina. From this it appears that *Elphidiononion* can be recognized as a genus close to *Elphidium*.

Cushman (1936, 1939) defined *Elphidiella* as "having two rows of openings at the sutures and with a thickened area between, without definite retral processes." He included in the genus the Recent *E. arctica* (Parker and Jones) and similar Late Tertiary to Recent species. Numerous species of *Elphidium* have been described with some individuals having double rows of septal pores. They represent a wide variety of forms from stout-walled *E. craticulatum* (Carpenter) which has retral processes, to more fragile *E. kerguelenense* Parr which has none, and which Parr (1950, p. 373) said "is intermediate between *Elphidium* and *Elphidiella*."

Double rows of septal pores and the lack of retral processes are frequently found to occur independently, and confusion in classification has arisen as various authors applied one or the other character as the essential criterion. Smout (1955, pp. 207-208) redefined *Elphidiella* placing so much emphasis on the lack of retral processes that he removed it to the family which he considered ancestral to the Elphidiidae, the Miscellancidae, in spite of its admittedly close relationship to *Elphidium*. Hofker (1956) emphasized the "primitive" canal system, septal pores, and lack of retral processes, while retaining it in the

Elphidiidae ("Polystomellidae") as a genus near (possibly ancestral to) *Elphidium*. Ujiie (1956) goes to the other extreme and places *Elphidium craticulatum* in *Elphidiella* presumably because of its double row of septal pores in the microspheric form, although it has retral processes. It may be difficult to decide whether a species in which the diverging canals are inclined to each other at a very low angle has one or two rows of septal pores. Ujiie illustrates this difficulty by drawing attention to "*Elphidiella momiyamaensis* Uchio, in which "two rows of sutural pores can hardly be observed even in large specimens." No consistent differences separate *Elphidium* from *Elphidiella*, so "*Elphidiella*" Cushman should be suppressed as a synonym of *Elphidium* Montfort. From Brotzen's description of *Elphidium primum* ten Dam, it seems that this species can be included in *Elphidium*, extending the recognized range of the genus to Danian. It will be necessary to re-study other pre-Eocene species referred to "*Elphidiella*" to see whether they too can be referred to *Elphidium*.

Loeblich and Tappan (1953) drew attention to the fact that *Criboelphidium* Cushman and Bronnimann (type species, *C. vadeseens* Cushman and Bronnimann) is a synonym of *Elphidium* Montfort. This fact has since been overlooked by several writers.

EMENDATION OF THE GENUS PARRELLINA THALMANN

Parrellina imperatrix (Brady), Recent, Port Jackson, New South Wales, *P. verriulata* (Brady), Miocene, Muddy Creek, Hamilton, Victoria, and *P. sp.* from the Oligocene, Table Cape, Wynard, Tasmania, were studied in addition to Parr's type material of *Parrellina* ("*Elphidioides*" Parr, not Cushman). In these species the fine, high, wavy lines of ornamentation which cover the test do not always coincide with the retral processes. There is a canal system of septal canals and diverging canals, such as is found in *Elphidium*. All these are extremely compressed, semievolute forms; tangential sections parallel to the median plane reveal anastomosing canals in the poorly developed umbilical thickening, rather than clear spiral canals. The septal canals also appear to lead into one another in a dendroid fashion similar to that which is much more clearly seen in *P. craticulatiformis*, n. sp. (described below). In tests with heavily thickened walls the diverging

canals do not open at the suture in fine septal pores, but wander on the lateral chamber-surfaces between the ridges of ornamentation. They do not occupy the position indicated by Parr (1950, fig. 7). In the figured specimen the dark lines which Parr figured as canals are an optical effect caused by the translucent shell material of the surface ridges, and coincide with the retral processes. The septal and diverging canals can only be seen in the cut surfaces and from the exterior. They may send several branches to the surface of the test. Hofker (1956, p. 161) noted the fact that the canals enter the marginal spines in *P. imperatrix*. In *P. verriulata* there may be long, deep slits between the ridges, rather than canals. Recent specimens of *P. imperatrix* have a row of fine apertural pores at the base of the apertural face. There may be more than one row of foraminal pores in the septal face.

Parr's definition (1950, p. 373) of *Elphidioides* (*recte Parrellina* Thalmann) should be emended to read:

Test planispiral, bilaterally symmetrical, involute to semi-involute; chambers numerous; sutures distinct, usually raised, connected across the intervening chamber surfaces by crossbars of rather wavy outline, sometimes anastomosing, which roughly coincide with the retral processes, the front of the last chamber also ornamented with raised ridges which radiate from near the base; wall calcareous radiate in structure; well-developed canal system with dendroid septal canals and diverging canals, septal pores small; aperture a series of fine pores near the base of the apertural face, often masked by the ornamentation.

Genus *Parrellina* Thalmann, 1951

Parrellina craticulatiformis, n. sp.

Fig. 4, 1-6

Test large, up to 1½ mm in diameter, thickness more than half the diameter, in side view each half the diameter, in side view each half is rounded. There is a slight thickened ridge at the narrowly rounded periphery. The chamber walls are ornamented by long, thin, rather irregular cross bars up to three or four times as long as the narrow, usually raised sutures are wide. No retral processes have been seen. The very low apertural face is finely fluted and has a row of deep depressions along the basal suture. These depressions may lead into apertural pores, as thin sections show the foramina to be rows of pores in this position. The septum is double.

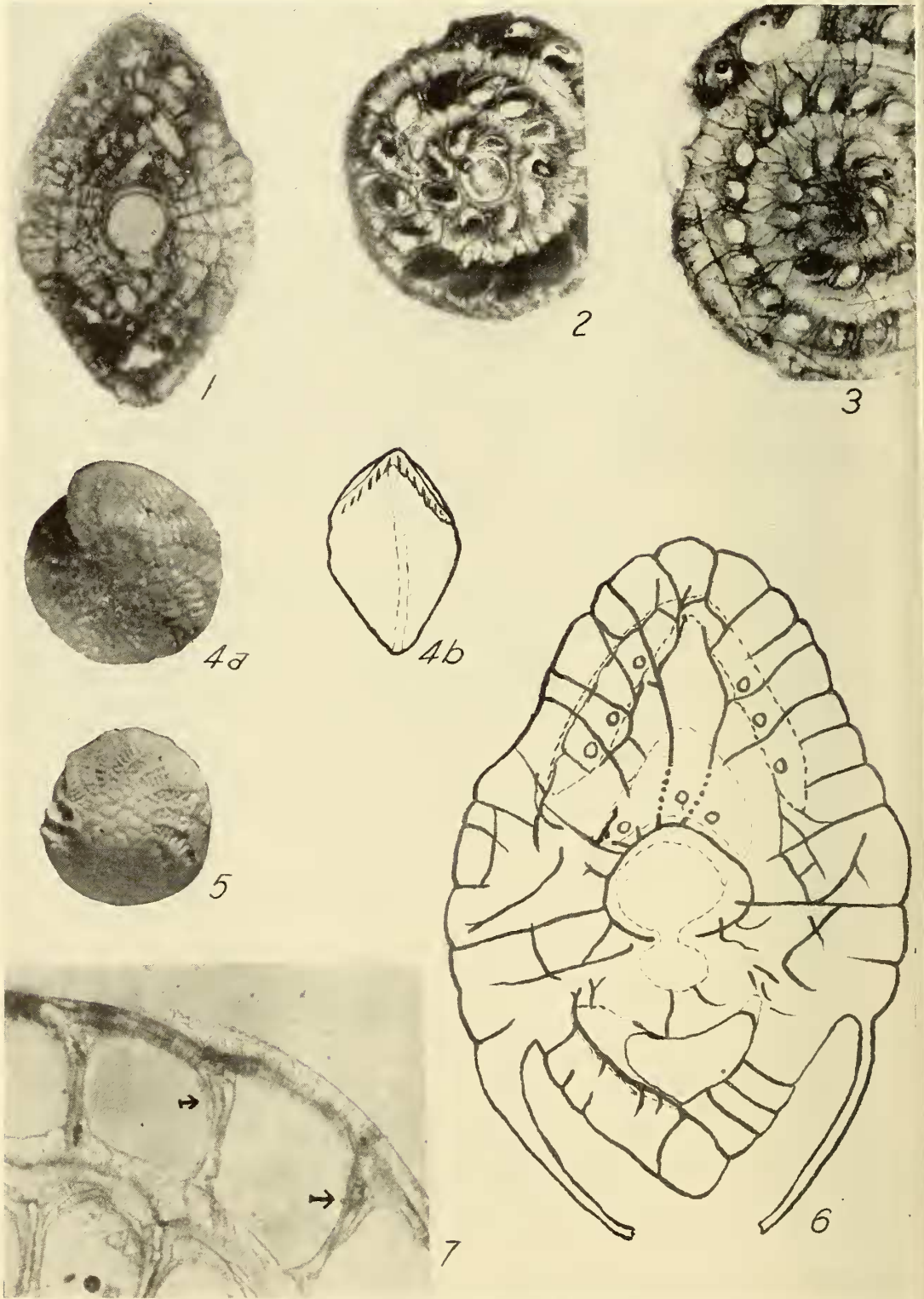


FIG. 4. (For explanation see opposite page).

The umbilical plugs are very large, formed by about fifteen to twenty bosses with pits between them. The pits are the openings of large radial umbilical canals some of which originate on either side of the initial whorl, smaller canals anastomose between the pillars of calcareous material which underly the bosses. Septal canals follow the outer edge of the septa, just below the septal sutures. No spiral canal is visible; the septal canals appear to join the small anastomosing canals in the umbilical plugs. Larger canals pass between the foraminal pores and across the septa between the two layers of which each consists. These canals branch and may join the septal canals, offshoots from both reaching the surface of the test as a row of fine pores (septal pits) along the suture. Near the periphery the branches (diverging canals) spread more widely in the thick spiral lamina, and their openings are not confined to the sutures. Some diverging canals lead into the lumina of chambers added above them; others pass between the layers of the septa, in the later whorls, rebranching, and extending to the surface of the test (Fig. 4, 2, 3, 6). The main canal system is this dendroid system, which can be traced to its origin in the walls of the initial chamber, in both megalospheric and microspheric specimens. The chambers are narrow and numerous, they range from about eight in the first whorl to over twenty in the outer wall of large specimens.

Dimensions.—As follows:

- Holotype, F15262, maximum diameter 1.06 mm, thickness 0.70 mm, Blanchetown.
 Paratype, F15263, maximum diameter 1.31 mm, thickness 0.91 mm, Blanchetown.
 Paratype, F15261, maximum diameter 1.36 mm, thickness 0.81 mm, Myponga Bore.

Occurrences.—Throughout the Lower Miocene section in the cliffs of the River Murray at Blanchetown, South Australia. Common. The type specimen from about 65 feet above sea

level, from the lowest sample with *Lepidocyclina gippslandica* subsp. Lower Miocene.

Bore near Myponga, South Australia, 296 to 495 feet. Common. *L. gippslandica* subsp. is present. Lower Miocene.

Remarks.—*Parrellina craticuliformis*, n. sp., is probably the species described as *Elphidium* sp. by Howchin and Parr (1938, p. 309, pl. 18, fig. 8), who had a single specimen from the Miocene of the Metropolitan Abattoirs Bore, Adelaide. As indicated by its specific name this species at first glance resembles *Elphidium craticulatum* (Brady) in its rotund proportions. Its ornamentation differs, however, and it lacks the clearly defined spiral canals of *E. craticulatum*, having anastomosing canals in the umbilicus in addition to the radial umbilical canals found in both species. Another difference is the subordination of the septal canals in *P. craticuliformis* to a dendroid intraseptal canal system which I have not found in *E. craticulatum* (Recent, New Guinea), though Carpenter (1862, p. 285; pl. 16, fig. 1) described a similar one from his much larger specimens. The species Parr (1950) referred to "*Elphidioides*" (*recte Parrellina* Thalmann), are rather delicate and do not have a completely double septum, hence they do not have an intraseptal canal system. This makes the similarity of their anastomosing umbilical canals, and the dendroid way the septal canals lead into each other (through some of the diverging canals) more striking. Similarly the diverging canals often spread a long way in the spiral lamina, particularly near the margin. It seems that *P. craticuliformis*, n. sp., is best placed in this genus, in spite of its lack of retral processes which must have been lost in this species.

SPECIES PREVIOUSLY DESCRIBED FROM AUSTRALIA

Described species of Australian fossil elphidiids have been investigated to check their generic assignments.

FIG. 4.—1-6, *Parrellina craticuliformis*, n. sp.: (1) Vertical section of a megalospheric specimen F15277, showing the radial and anastomosing umbilical canals; (2) horizontal section of a megalospheric specimen, F15276, showing double septa and the dendroid canal system; (3) horizontal section, microspheric, F15275, cut at the side of the initial whorl to show the dendroid canal system radiating from the earliest part of the test; some cleavages are visible as straight dark lines in the spiral lamina (1-3 approx. $\times 40$); (4) holotype, F15262, $\times 30$ (a lateral view, b Outline, showing thick test, blunt keel, and low, ornamented, apertural face); (5) specimen from Myponga, showing umbilical bosses and fine ornamentation; (6) drawing of vertical section F15274, $\times 100$, showing dendroid intraseptal canal system, and foramina in the septa. 7, *Elphidium craticulatum* (Fichtel and Moll): The arrows point to septal canals enclosed between the septal face and septal flap, with a retral process on the peripheral side, as in Fig. 1b. $\times 200$.

Elphidium adelaidense Howchin and Parr (1938), *E. rotatum* Howchin and Parr (1938), and *E. chapmani* Cushman (1936) were obtained from the Pliocene of the Adelaide Plains Basin, South Australia. *E. macellum* (Fichtel and Moll) var. *limbatum* Chapman (1907) is common in the Pliocene of Jemmy's Point, Kalimna, Victoria. *E. pseudonodosum* Cushman (1936) also occurs there and in the Pliocene at Muddy Creek, near Hamilton, Victoria. Topotypes of *E. crespinae* Cushman (1936) were obtained from the Miocene of Muddy Creek. It seems that *E. crassatum* Cushman (1936), which was also described from the Miocene of Muddy Creek, is synonymous with the larger variants of *E. crespinae*. *E. parri* Cushman (1936) is also present in the Miocene of Muddy Creek. All these species are correctly assigned to *Elphidium*, and all have true retral processes. No specimens of *Elphidium evolutum* (Chapman, 1913) were available.

No specimens of *E. subinflatum* Cushman (1936), which has the ornamentation typical of a *Parrellina*, were available, and only one specimen of the closely similar *E. pseudoinflatum* Cushman (1936), from the Miocene of Muddy Creek. This species has large septal pores and no ornamentation on the septal face; it is strongly involute with the umbilical regions depressed. It appears to be an *Elphidium* rather than a *Parrellina*, in spite of its thin, wavy ornamentation. It is not possible to give a firm opinion on the classification of these species until adequate material for thin-sectioning becomes available.

Parrellina imperatrix (Brady, 1884) is found rarely in the Pliocene at Jemmy's Point, Kalimna (Parr, 1950). *P. verriculata* (Brady, 1884) is found in the Miocene at Muddy Creek. A closely similar species (*P.* sp. of this paper) is both common and widespread in slightly older beds in South Australia and at Table Cape, Wynyard, Tasmania. No specimens of "*Elphidium*" *howchini* Cushman (1936) have been found. A closely similar species of *Parrellina* which lacks the transverse ornamentation on the apertural face, occurs in the Oligocene of Table Cape.

Notorotalia miocenica (Cushman, 1936) is common in the Miocene at Muddy Creek. *N. howchini* (Chapman, Parr, and Collins, 1934) is very common and widespread in the Middle Tertiary of South Australia, one specimen was found in the Pliocene of the Adelaide Plains Basin.

N. aff. tainuia Dorreen (1948) is common and widespread in the Oligocene of South Australia.

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WOOD-BORING BEETLES

The Smithsonian Institution has recently obtained a large and important collection of wood-boring beetles, to be added to the entomological series of the United States National Museum. The new collection, numbering more than 100,000 specimens and representing about 16,500 species of this enormous group of insects, came from Frederick F. Tippmann, an engineer, explorer, and entomologist of Vienna, Austria. He assembled the collection over a period of 40 years, not only collecting personally in every country of South America and in Africa, Asia, and Europe, but also purchasing great rarities from many remote parts of the world.

The wood-boring beetles of this family, numbering in all about 25,000 species, comprise one of the economically most important groups of insects of the world. In the larval stage they attack wood and stems of woody and herbaceous plants, and a few of them eat seeds. It is on record that one small outbreak of one species, affecting only 8 square miles of forest, killed 45,000 trees, aggregating nearly 1,000,000 cubic feet of timber. Fig-growing is impossible in some parts of India because of the damage caused by another species. In one area of China 90 percent of all citrus trees are infested by a wood-borer, and many young trees are killed annually in spite of preventive measures. Other species attack rafters of houses, particularly in con-

tinental Europe, furniture, rustic garden work, telegraph poles, and orchids.

Not all species, however, are harmful, point out Smithsonian entomologists. Live-stem borers are used to control the spread of noxious plants such as lantana. Larvae of several groups speedily break down stumps and discarded logs in coniferous plantations, greatly enriching the soil and clearing the ground. Some kinds indicate to the forester that his trees are unhealthy and are the victims of more serious foes.

These beetles range in size from minute specimens about $\frac{1}{16}$ inch long to monsters 4 to 5 inches in body length with 8-inch antennae. Every conceivable color is represented, and many mimic the form of other beetles, wasps, flies, and so forth.

The newly acquired collection, together with others already assembled at the United States National Museum, will permit studies embracing the biology and distributional features of the wood-boring insects and will be available to interested students of beetles who wish to undertake studies in this group. It is only through long and careful study using a working tool such as this important collection, that scientists are able to learn about both the useful and destructive forms of insects and how to distinguish between them.